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PATENT SPECIFICATION

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(54) RADIATION THERMOMETER

(71) We MULLARD LIMITED of Abacus House, 33 Gutter Lane, London, E.C.2. a British Company do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a radiation thermometer and especially to such a thermometer where the temperature sensed is relatively close to the ambient temperature. Such a case is where it is desired to sense the temperature of the human body which is approximately 35°C and which is quite close to the ambient temperature which normally lies around 20°C.

The present invention is a radiation thermometer in which a measuring signal alternately representing a temperature to be measured and the ambient temperature is added to a correction signal having the same frequency as that of the measuring signal, the amplitude of the correction signal being dependent upon the ambient temperature and varying with variations thereof, the signals when summated being used to give a true indication of the temperature to be measured.

The above and other features of the present invention will be more readily understood by a perusal of the following description having reference to the drawings accompanying the Provisional Specification in which:—

Figure 1 is a block diagram of a radiation thermometer incorporating the present invention; and

Figures 2 and 3 are circuit diagrams of part of Figure 1.

Referring now to Figure 1 there is shown a radiation thermometer which is employed as a clinical thermometer to cover the temperature range of 30 to 40°C. Heat radiated from a body where temperature is to be sensed is passed through a light pipe 1. a chopper disc 2 and a filter 3 to fall on an infra-red cell 4 which may be of the indium antimonide type. As the chopper disc 2 rotates the cell 4 alternately sees the body to be sensed through apertures in the disc and the blank segments of the disc which will be at the ambient temperature.

The temperature measuring signal having a square wave thus produced at the cell 4 is amplified by a pre-amplifier 5 and a main amplifier 6 to provide a signal of a usable magnitude. To obtain a true measure of body temperature it is necessary to measure both the differences between ambient and body temperature, and the ambient temperature. Also provided in the path of the chopper disc 2 is a light emitter 7 which may be of the gallium arsenide type and a light detector 8. This arrangement provides a reference square wave signal having the same frequency as that of the output from the cell 4 and which is amplified by an amplifier 9 and used to switch a phase sensitive rectifier 10. The amplified reference signal is also employed to provide a correction signal for the ambient temperature, the reference signal being applied to an ambient temperature sensor 11 the output of which (the correction signal) is passed to an adder circuit 12 together with the output from the main amplifier 6. The output from the adder circuit 12 is amplified in an amplifier 13 and passed to the phase sensitive rectifier 10 the output from which is displayed on a meter 14. As it was desired to make the radiation thermometer compact the chopper disc was driven by a clockwork motor instead of an electric motor, as an electric motor would provide electrical noise from the commutator and interference by changing magnetic fields. In addition an electric motor would place quite a high demand on a battery power supply.

Figure 2 shows the method in which the infra-red cell 4 and light emitter 7 were biased from a battery supply. As shown in the Figure the battery supply V_s is connected through a resistor R_1 and a zener diode D_1 to earth, the junction of these two elements being connected through the light emitter 7

and a resistor R_2 to one terminal of the infra-red cell 4 and the other terminal of which is also connected to earth. The resistor R_2 and cell 3 are decoupled by a capacitor C_2 whilst the zener diode D_1 is decoupled by a further capacitor C_1. The square wave (chopped) output present at the junction of resistor R_2 and cell 4 being the measuring signal is connected into the pre-amplifier 5, which itself is connected to the main amplifier 6.

Figure 3 shows a detailed circuit arrangement of the blocks 8, 9, 10, 11 and 12 of Figure 1. In Figure 3 the light detector 8 which is in the form of a photo diode connected across the base-collector junction of a transistor has one terminal connected to the supply V_s whilst its other terminal is connected through a resistor R_3 to earth.

The reference signal present at the junction of these two components is applied to the amplifier 9, through a capacitor C_3 to the base electrode of a n-p-n transistor TR_1 biased by a potential divider formed by resistors R_4 and R_5. The emitter resistor for this transistor is in the form of a variable resistor RV_1 which is decoupled by a capacitor C_4. This variable resistor allows adjustments of the shape to the output signal so that the waveform can be made symmetrical about the mean level. The collector load for transistor TR_1 is formed by a resistor R_6 and two outputs are derived from the collector circuit by way of capacitors C_5 and C_6. The output derived from capacitor C_5 is applied to the ambient temperature sensor 11 to the base electrodes of two n-p-n transistors TR_2 and TR_3, connected as a differential amplifier. The input to the base electrode of transistor TR_2 is applied across a fixed pre-set potential divider formed by a resistor R_7 and a variable resistor RV_2 whilst the input to the base electrode of transistor TR_3 is applied across a variable potential divider formed by a negative temperature coefficient resistor R_8 and a variable resistor RV_3. In both cases the signal is applied from the potential divider to the base electrodes of the transistor by a capacitor (C_7 and C_8), whilst the base electrodes are biased from a potential divider formed by two resistors R_9 and R_{10} (shown in block 12) through a series resistor (R_{11} and R_{12}), the centre point of this potential divider being decoupled by a capacitor C_9. The emitter electrodes of transistors TR_2 and TR_3 are each connected through a resistor of equal magnitude (R_{13} and R_{14}) to a common emitter resistor R_{17} whilst the collector electrodes are connected through resistors of equal magnitude (R_{15} and R_{16}) to the supply V_s. The correction signal output from the ambient temperature sensor circuit is derived from the junction of TR_3 collector electrode with resistor R_{16} and will be dependent on the signal applied to the base electrode of transistor TR_3 which itself will be dependent upon the resistance of the N.T.C. resistor R_8 which is controlled by the ambient temperature. The variable resistor RV_2 is provided to back off excess reference signal and radiated signal in order that the range of the meter 14 may only start at 30°C. The pre-set resistor RV_3 can be adjusted to provide the right amount of corrected reference signal variation relative to the temperature sensed signal. The output from the ambient temperature sensor circuit 11 is passed to the adder circuit 12 through a capacitor C_{10} to the base electrode of an n-p-n transistor TR_4 which together with a further n-p-n transistor TR_5 operates as a differential amplifier. The base electrodes of these two transistors are again biased from the potential divider formed by resistors R_9 and R_{10}, a series resistor (R_{17} and R_{18}) also being provided between the junction on the potential divider and each base electrode. The signal from the main amplifier 6 is applied through a capacitor (not shown) to the base electrode of transistor TR_5. The emitter electrodes of transistors TR_4 and TR_5 are connected through resistors of equal value (R_{19} and R_{20}) to a common resistor R_{21} and hence to earth, whilst the collector electrode of transistor TR_4 is connected to the supply V_s through a variable resistor RV_4 and the collector electrode of transistor TR_5 is connected to the supply V_s through a fixed resistor R_{22}. The inputs to the base electrodes of transistors TR_4 and TR_5 are arranged to be 180° out of phase with each other so that the output from the collector electrode of transistor TR_4 corresponds to the sum of the two signals. The variable resistor RV_4 provides adjustment of gain to enable a correct reading to be obtained on the meter 14. This output is applied to an amplifier 13 having a low output impedance which in turn feeds the phase sensitive rectifier 10.

The phase sensitive rectifier is formed by two transistors TR_6 and TR_7 which are of opposite conductivity types TR_6 being of the p-n-p type whilst TR_7 is of n-p-n type. The collector electrodes of these two transistors are directly connected to earth whilst their emitter electrodes are connected through resistors of equal value (R_{23} and R_{24}) to a capacitor C_{11} which is connected to the output of the amplifier 13. The base electrodes of transistors TR_6 and TR_7 are connected through resistors of equal magnitude (R_{25} and R_{26}) to the capacitor C_6 in the reference signal amplifier 9. Between the emitter electrodes of transistors TR_6 and TR_7 is connected the moving coil meter 14 which is shunted by a capacitor C_{12} to reduce the band width of the measuring system to reduce noise. With the application of the reference signal to the base electrodes, one of the transistors (TR_6 or TR_7) at a given time will be conducting and the other non-conducting and signal

current will flow in one direction through the meter 14. At the end of each half cycle these conditions are reversed as is the sense of the temperature signal so that the signal current will always flow through the meter in the same direction.

Although in the above description the invention has been described with reference to a clinical thermometer it may readily be employed in other temperature measuring arrangements where the temperature to be measured is close to the ambient temperature.

WHAT WE CLAIM IS:—

1. A radiation thermometer in which a measuring signal alternately representing a temperature to be measured and the ambient temperature is added to a correction signal having the same frequency as that of the measuring signal, the amplitude of said correction signal being dependent upon the ambient temperature and varying with variations thereof, said signals when summated being used to give a true indication of the temperature to be measured.

2. A radiation thermometer as claimed in Claim 1 in which the measuring signal is produced by a detector cell sensitive to infrared radiation.

3. A radiation thermometer as claimed in Claim 2 in which in front of said detector cell there is provided a rotatable apertured chopper disc, said detector cell producing a first signal level representing the temperature to be measured when said detector cell can view through the apertures of the chopper disc.

4. A radiation thermometer as claimed in Claim 3 in which said detector cell produces a second signal level representing the ambient temperature when said detector cell views the segments of said chopper disc between its apertures, said chopper disc being at the ambient temperature.

5. A radiation thermometer as claimed in Claim 3 or 4 in which said apertured chopper disc is also employed to produce a reference signal.

6. A radiation thermometer as claimed in Claim 5 in which a light source is provided on one side of said apertured chopper disc and a light detector provided on the other side of said disc, said reference waveform being produced by said light detector.

7. A radiation thermometer as claimed in Claim 5 or 6 in which said reference waveform is applied to an ambient temperature sensor to produce the correction signal.

8. A radiation thermometer as claimed in Claim 7 in which the ambient temperature sensor circuit comprises a differential amplifier.

9. A radiation thermometer as claimed in Claim 8 in which the reference signal is applied to both inputs of said differential amplifier, the input path to one input including a temperature sensitive element.

10. A radiation thermometer as claimed in Claim 9 in which said temperature sensitive element is a resistor having a negative temperature coefficient.

11. A radiation thermometer as claimed in any preceding Claim in which the measuring signal is applied to a first input of a differential amplifier whilst the correction signal is applied to a second input of the differential amplifier, said applied signals being arranged to be 180° out of phase, the output of the differential amplifier being the sum of the applied signals.

12. A radiation thermometer as claimed in Claim 11 as dependent on any of the Claims 5 to 10 in which the summated signals are applied to a phase sensitive rectifier synchronised by the reference signal.

13. A radiation thermometer as claimed in Claim 12 in which the output from the phase sensitive rectifier is applied to a meter calibrated to indicate the temperature to be measured.

14. A radiation thermometer as claimed in Claim 6 as dependent upon Claim 2, 3 or 4 in which the light source is a gallium arsenide light emitter and the detector cell is of the indium antimonide type, said light emitter and said detector cell being serially connected across and biased by a power supply for said thermometer.

15. A radiation thermometer substantially as herein described with reference to the drawings accompanying the Provisional Specification.

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1,226,540 PROVISIONAL SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

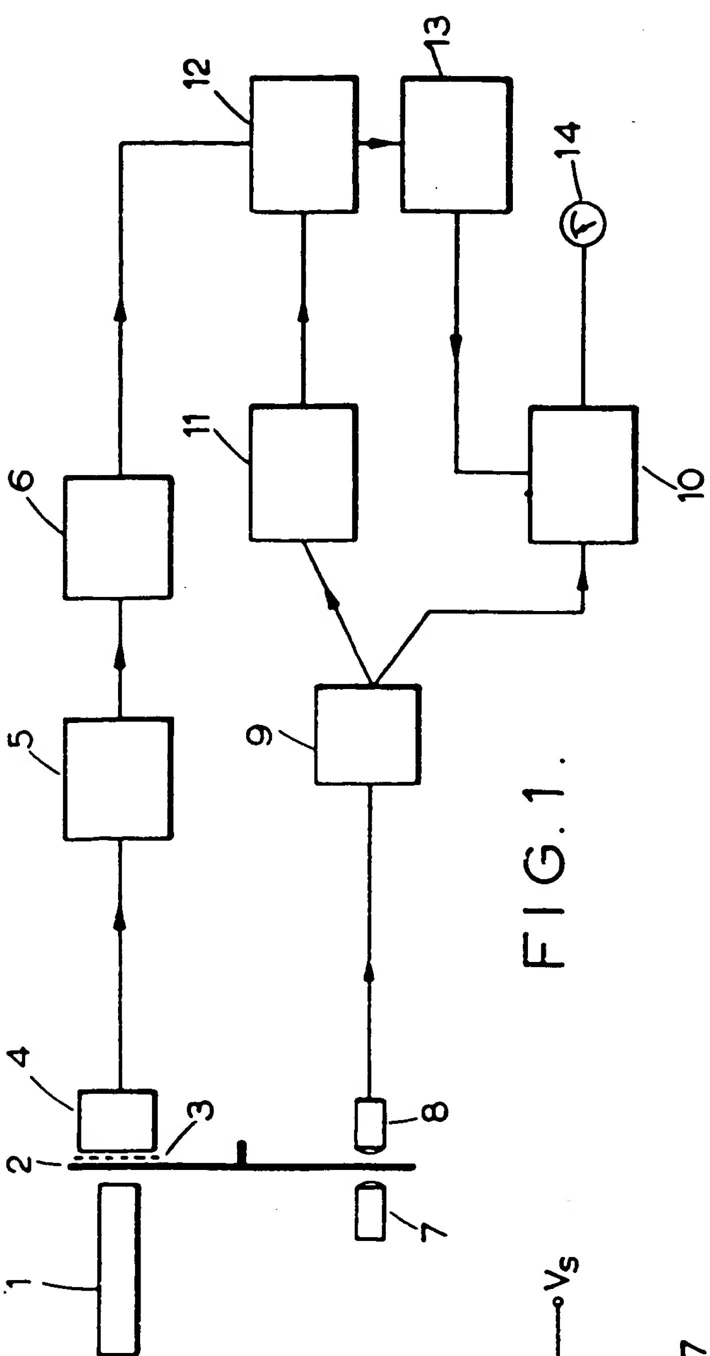

FIG. 1.

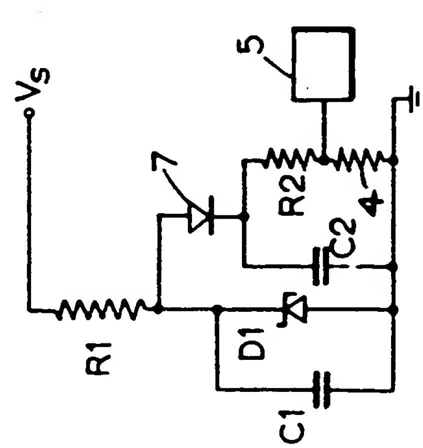

FIG. 2.

1,226,540 PROVISIONAL SPECIFICATION

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SHEET 2

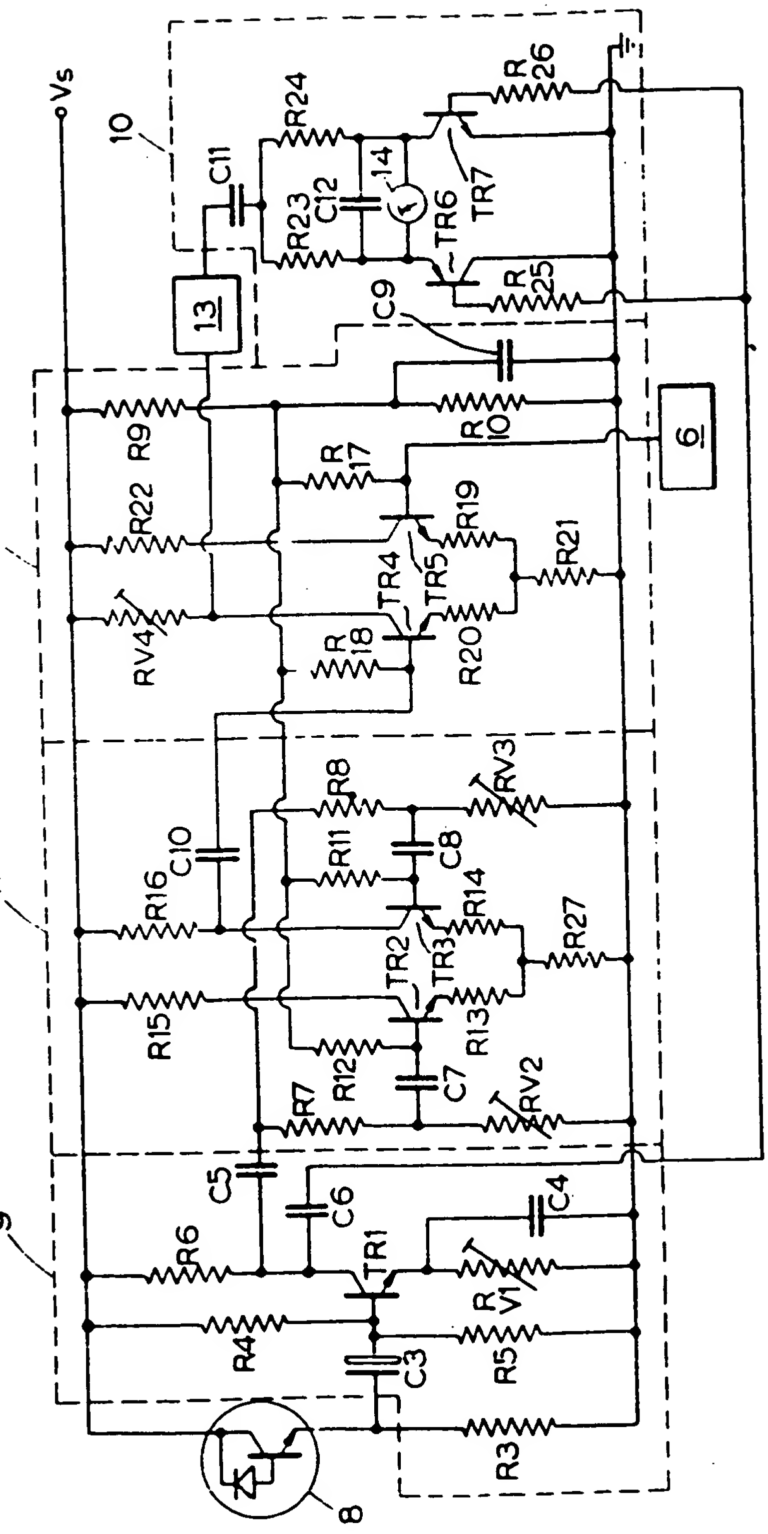

FIG. 3.